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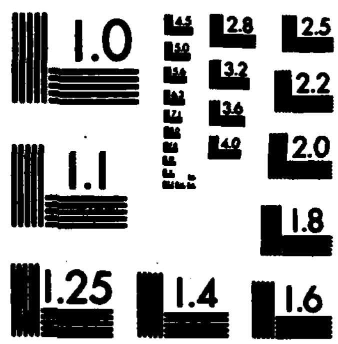

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The general objective of this research project is to study radiative transitions in atoms and molecules especially those relevant to infrared radiation. For the 8/83 - 7/84 period our major efforts include (i) electron-impact excitation of low-Rydberg states of N_2, (ii) production of excited oxygen atoms by electron-impact dissociation of O_2, (iii) a new method for measuring metastable atom number density, (iv) collision behaviors of Na atoms.

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Annual Technical Report: 1 August 1983 - 31 July 1984

Grant Number AFOST-83-0312

Principal Investigator: Chun C. Lin

The general objective of this project is to study radiative transitions in atoms and molecules, particularly those which are relevant to infrared radiation. During the period of 1 August 1983 - 31 July 1984, our major efforts were in the following areas:

(i) Experiments on electron-impact excitation of the $D^3\Sigma_u^+$ and $c'_4{}^1\Sigma_u^+$ electronic states of the N_2 molecule have been performed and the absolute optical emission excitation cross sections have been measured for the $D^3\Sigma_u^+ \rightarrow B^3\Pi_g$ and $c'_4{}^1\Sigma_u^+ \rightarrow a^1\Pi_g$ transitions for incident electron energies from threshold to 400 eV. The $D^3\Sigma_u^+$ and $c'_4{}^1\Sigma_u^+$ electronic states of N_2 are of special interest since they are the first member of the Rydberg series of the triplet family and the singlet family respectively. The excitation function (excitation cross section as a function of incident electron energy) of the $D^3\Sigma_u^+ \rightarrow B^3\Pi_g$ emission has a sharp peak at 14 eV, a smaller maximum at 23 eV, and an E^{-3} energy dependence for incident electron energies $E > 65$ eV. The double-maximum feature is not due to cascade, but may possibly result from a negative-ion-type resonance. For the excitation function of the $c'_4{}^1\Sigma_u^+ \rightarrow a^1\Pi_g$ emission, we find a single very broad maximum near 80 eV and for $E > 100$ eV an energy dependence described by $(\ell nE)/E$.

(ii) Passage of an electron beam to a chamber containing O_2 molecules produces excited O_2 molecules in bound electronic states as well as unbound states. In the latter case the excited molecule dissociates into two oxygen atoms with one or both in excited states. To study this process we measure the radiation from the excited oxygen atoms produced by electron impact on O_2 molecules. We have measured absolute optical emission cross sections for some sixty transitions originating from excited electron configurations

$1s^2 2s^2 2p^3 n\ell$ (n=3,4,5,6,7,8) of the oxygen atom produced by incident electron energy from threshold to 500 eV. (Production of oxygen atoms in the highly excited levels is of special interest because such highly excited atoms are sources of infrared radiation.) Studies of detailed characteristics of the energy dependence of the cross sections (including the appearance potential) allow us to identify the key mechanisms for producing the excited oxygen atoms in the electron-impact dissociation experiment.

(iii) We are working on a new method for determining the number density of metastable atoms produced by electron-beam excitation of ground-state atoms, and have applied it successfully to neon. We generate metastable Ne atoms (in the $1s^2 2s^2 2p^5 3s$ electron configuration) by an electron beam through a container of Ne atoms. A pulsed laser, tuned to the absorption frequency of one of the $1s^2 2s^2 2p^5 3s \rightarrow 1s^2 2s^2 2p^5 3p$ transitions, pumps the metastable atoms to a $1s^2 2s^2 2p^5 3p$ level. With a high-power pulsed laser we saturate the transition, i.e., transfer the atoms from the $1s^2 2s^2 2p^5 3s$ metastable level to the higher $1s^2 2s^2 2p^5 3p$ level to equalize the population of these two levels. The number of photons emitted from this $1s^2 2s^2 2p^5 3p$ level after cessation of the laser pulse is measured and used to determine the number density of the metastable Ne atom number density. At a Ne gas pressure of 15 mTorr, an electron beam current density of 0.016 A/cm^2, and an electron beam energy of 100 eV, we find the number density of the metastable Ne atoms in the $1s^2 2s^2 2p^5 3s$, J=2 level to be 9×10^8 cm^{-3}. Comparing this with the ground-state atom number density of 5×10^{14} cm^{-3}, we find a metastable atom concentration of about one or two parts in 10^6.

(iv) As a preparation for our plan of studying excitation of the Ne($1s^2 2s^2 2p^5 3s$) metastable atom to higher levels like $2s^2 2s^2 2p^5 n\ell$, we try to have some indications as to the behaviors of the 3s electron of the metastable atom under various collision conditions. The 3s electron is a "lone" electron in an outer shell and relatively loosely bound, so it is in some way similar to the 3s electron in a ground-state Na atom ($1s^2 2s^2 2p^6 3s$). Because of its small binding energy, the 3s electron can be readily excited to the higher levels, ionized, or, upon colliding with another atom, may transfer to the collision partner. Thus we have conducted collision experiments of Na atoms with H^- ions and neutral H atoms as projectiles, and determined the cross sections of $3s \rightarrow 3p$ excitation and of electron transfer, $H + Na \rightarrow H^- + Na^+$. These data will be a useful guide for selecting our experiments on excitation of the metastable Ne atoms.

<u>Publications</u>

"Excitation of the Na(3p) Level by H^- Ions and H^0 Atoms", Physical Review Letters <u>51</u>, 2029 (1983).

"Charge Changing Cross Sections for 1-25 keV H(1s) Incident on a Na Vapor Target", Physical Review A <u>29</u>, 1083 (1984).

"Electron-Impact Excitation of the $D\,^3\Sigma_u^+$ and $c_4'\,^1\Sigma_u^+$ Rydberg States of N_2", Physical Review A <u>29</u>, 1709 (1984).

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